APPENDIX B

Measuring Ionization Chamber (MIC)

This appendix includes selected pages from the measuring ionization chamber (MIC) instruction manual that discuss the theory of operation and the outputs from the instrument.

4. THEORY OF OPERATION

4.1 General working principle for ionization chambers for smoke density measurements

The use of ionization chambers as smoke sensors is well known and the associated theory outlined in the literature.

The working principle for the ionization chamber for smoke density measurements is shown in *fig. 4.1.*

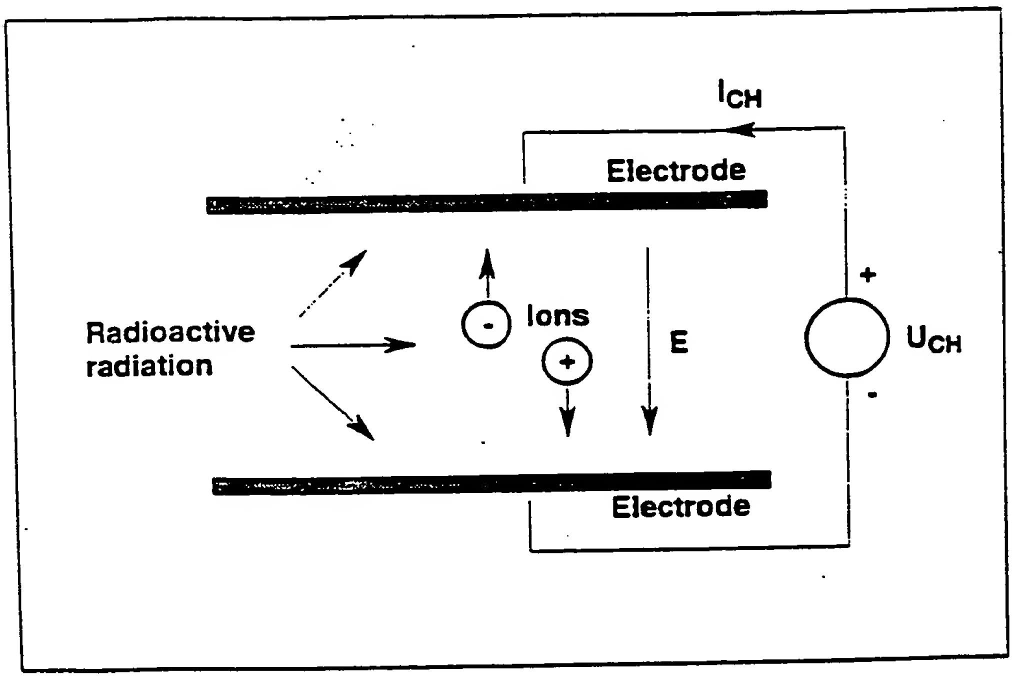

FIG. 4.1 Working principle for ionization chamber

The chamber consists of a pair of electrodes between which a volume of atmospheric air is present. The electrodes are connected to a voltage source U_{CH} so an electrical field E is applied to the air. Radioactive radiation from a small radioactive source bombards the air and ion pairs are created between the electrodes. The positive and negative air molecules forming the ion pairs are deflected towards the negative and positive electrode, respectively. Some of the ions recombine before they reach the electrode surfaces and become neutral air molecules. Other ions exchange electrons with the electrode surfaces. This electron exchange results in a small electrical current I_{CH} in the external circuit.

When the air between the electrodes is clean, the ions formed move to the electrode with a certain mean velocity and each ion which does not recombine in the volume contributes to the current. However, if smoke particles penetrate the volume between the electrodes, the ions and the smoke particles will be attached to each other with a certain probability. Since the smoke particles are much heavier than the ions, the mobility of ions attached to smoke particles is greatly reduced and the probability for recombination increased. So, their contribution to the external current becomes negligible. Thus the external current is a function of the smoke particle density in the measuring volume.

The smoke density can be defined in terms of X as follows:

$$X = \frac{I_{CHO} - I_{CH}}{I_{CHO}} \quad (0 \leq X \leq 1) \tag{4.1.1}$$

I_{CHO}[A] is the chamber quiescent current (clean air)
I_{CH}[A] is the chamber current when smoke is present

It appears from eq. 4.1.1 that X = 0 in clean air and X = 1 when the smoke density is infinite.

Smoke density can also be expressed in Y-values which are related to the X-values as follows [1]:

$$Y = X \cdot \frac{2-X}{1-X} \tag{4.1.2}$$

The Y-value can also be transferred to a value related to a chamber voltage of 20 V. This Y_{20}-value is related to the Y-value as follows:

$$Y_{20} = \frac{Y}{U_c} \cdot 20 \tag{4.1.3}$$

The advantage of expressing the smoke density in terms of Y- and Y_{20}-values is that these values are proportional to the number of smoke particles per unit volume.

Besides smoke density, the X-, Y-, and Y_{20}-values depend on the design of the ionization chamber and a number of environmental parameters.

So, the readings obtained from different ionization chamber configurations cannot be compared unless the correction factor for the chambers is known, e.g. from calibration.

4.2 Measuring Ionization Chamber (MIC)

4.2.1 Ionization chamber design

The MIC has a parallel plate electrode configuration in which the radioactive source (Am 241) is part of one of the electrodes. This configuration provides a measuring volume in which the ionization is uniform and approx. parallel to a constant electrical field.

The air is sucked through the chamber in order to reduce wind dependence, but the air in the measuring volume between the electrodes is stationary since the sucked air flows in a duct which is separated from the measuring volume by means of a wire mesh. Smoke is transferred from the air flow to the measuring volume by diffusion.

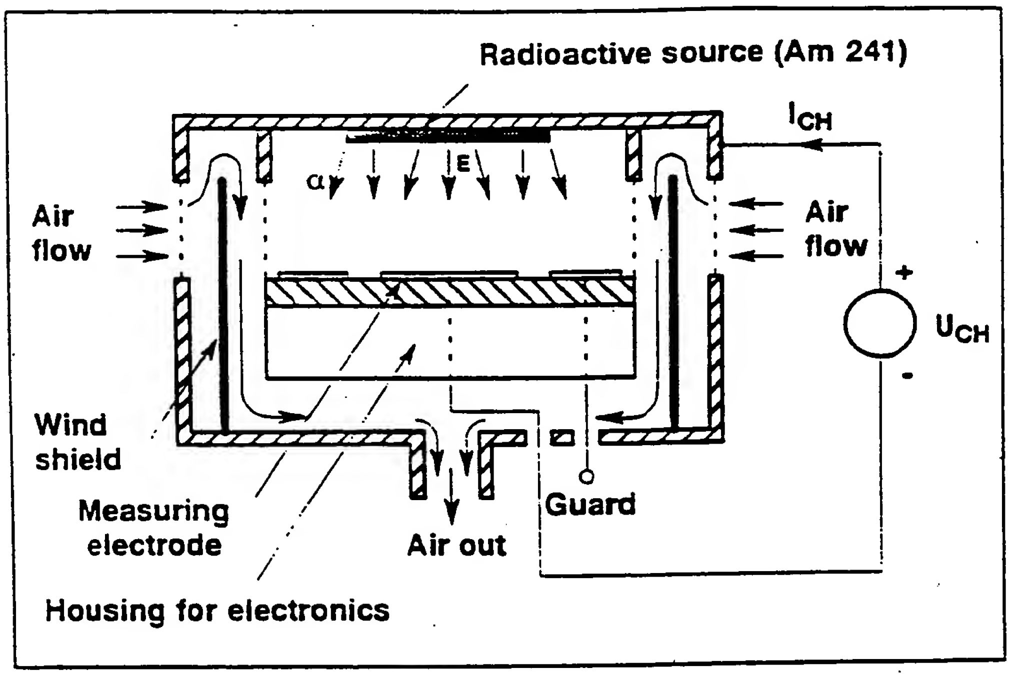

FIG. 4.2.1 Principle of ionization chamber design in the MIC

The radioactive source is mounted in a holder which may be unscrewed for cleaning purposes, refer to *section 5.1.1.*

The chamber is operated in the proportionality range with a clean air quiescent current of 10^{-10}A (100pA) corresponding to a chamber voltage of approx. 19 V.